



UNIVERSITI PUTRA MALAYSIA

**DISTRIBUTION OF PELAGIC FISH SPECIES IN THE JAVA SEA
FROM REMOTE SENSING DATA**

WIJOPRIONO.

FH 2006 2

**DISTRIBUTION OF PELAGIC FISH SPECIES IN THE JAVA
SEA FROM REMOTE SENSING DATA**



WIJOPRIONO

**DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA
2006**

**DISTRIBUTION OF PELAGIC FISH SPECIES IN THE JAVA SEA
FROM REMOTE SENSING DATA**

By

WIJOPRIONO

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements For the Degree of Doctor of Philosophy**

January 2006



DEDICATION

This thesis is dedicated to my beloved parents, wife, and daughter:

Djamin Sastro Suwito and late Widjiati;

Dwi Irianingsih, Siswoyo Budi Priono, Jodi Azhar Priono and Kemala Adi Citra

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in
fulfilment of the requirement for the degree of Doctor of Philosophy

**DISTRIBUTION OF PELAGIC FISH SPECIES IN THE JAVA SEA
FROM REMOTE SENSING DATA**

By

WIJOPRIONO

January 2006

Chairman : Professor Kamaruzaman Jusoff, PhD

Faculty : Forestry

Pelagic fishery in the Java Sea is multi-species and dominated by a community of small pelagic species. This study attempted to employ different sources of data in order to determine the distribution of pelagic fish species and to estimate their environmental preferences. Catch per unit effort (CPUE), hydro-acoustic, satellite derived sea surface temperature (SST) and chlorophyll-a data as well as oceanographic *in situ* measurements data were used to achieve these objectives. CPUE data were collected from commercial fishing records available at the fishing port of Pekalongan, the main pelagic fish landing centre in the north coast of Java. Hydro-acoustic and oceanographic *in situ* measurements data were collected from hydro-acoustic survey carried out during September-October 2002, while the data of satellite derived SST of AVHRR-NOAA and chlorophyll-a derived from SeaWiFS were collected from the HRPT (High Resolution Picture Transmission) ground receiving station at BPPT (Assessment and Application of Technology Board), Jakarta, and GSFC-NASA (Goddard Space and Flight Center of the National Aeronautics and Space Administration). Correlation analysis, cluster analysis, PCA, spatial analysis and GIS technique were employed in determining abundance and

density distribution of pelagic fish species. Spatial analysis and GIS technique together with GLM were also applied in building the fishery-environment dependent model in order to estimate the environmental preferences of the fishes. Results of the study showed that the Java Sea water was seasonally occupied by oceanic water of the Indonesian Throughflow (ITF). The influence of the ITF was most pronounced in the southeast monsoon when the currents in the Java Sea flow towards the west. The influence is minimum in the northwest monsoon when the currents flow towards the east. The sea has a great thermal stability with a monthly SST average of 28.9 °C and the difference between maximum and minimum (gradient) of 2.0-3.5 °C. The abundance of phytoplankton tends to increase towards the west and towards the coastal areas off north coast of Java, south coast of Kalimantan, and around the small islands spreading over the Java Sea. Correlations between physical and biological oceanographic parameters were exhibited. Pelagic fishery resources in the Java Sea have undergone considerable variations in both their seasonal distributions and abundances. They were relatively low during northwest monsoon (December-March), and increased during southeast monsoon (June-September), with a peak at the end of the monsoon. Abundance of the resources was mostly driven by fluctuations in the abundance of one dominant species, *Sardinella* spp in the inshore and *Decapterus* spp in the offshore. The two species make up the average of 36% and 32% of the total CPUE, respectively. GLM model gave evidence that the pelagic fish species have a tolerance limit of temperature of up to 28.5 °C, and below this temperature limit they show a positive trend of relationships with chlorophyll-a concentrations. The model also revealed that oceanographic variables (SST and chlorophyll-a concentrations) contributed 54% to the total variance explained by the GLM predictors, confirming the relative importance of these variables in predicting

pelagic fish catch. However, relationship between sea surface temperature and chlorophyll-a concentrations was weak. The GIS model has demonstrated its capability in delineating spatial patterns of fish density in relation to the environmental variables, especially zooplankton, which was not covered in the GLM model.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**TABURAN SPESIES IKAN PELAGIK DI LAUT JAWA
DARI DATA PENDERIAAN JAUH**

Oleh

WIJOPRIONO

Januari 2006

Pengerusi : Profesor Kamaruzaman Jusoff, PhD

Fakulti : Perhutanan

Perikanan pelagik di Laut Jawa adalah multi-spesies dan dikuasai oleh komuniti spesies ikan pelagik kecil. Kajian ini menggunakan pelbagai sumber data yang berbeza bagi memastikan penyebaran spesies ikan pelagik dan menganggarkan keutamaan persekitaran mereka. Data hasil tangkapan per unit daya (CPUE), hidro-akustik, suhu permukaan laut (SST) dan klorofil-a daripada satelit, dan data oseanografi daripada pengukuran *in situ* digunakan bagi mencapai objektif kajian. Data CPUE diperolehi daripada rekod hasil tangkapan ikan komersil yang di Pelabuhan Perikanan Nusantara Pekalongan, iaitu pusat pendaratan ikan pelagik utama di pantai utara Jawa. Data hidro-akustik dan data oseanografi berdasar kepada pengukuran *in situ* diperolehi daripada hasil kajian hidro-akuatik yang dilaksanakan pada bulan September-Oktober 2002, manakala data SST dan klorofil-a daripada AVHRR-NOAA dan SeaWiFS diperolehi daripada stesen penerima resolusi tinggi (HRPT) Badan Pengkajian dan Penerapan Teknologi (BPPT), Jakarta, dan GSFC-NASA (Goddard Space and Flight Center of the National Aeronautics and Space Administration). Analisis korelasi, analisis kelompok, PCA, analisis ruang dan teknik GIS (geographic information system) digunakan bagi memastikan kelimpahan dan

kepadatan taburan spesies ikan pelagik. Analisis spasial dan teknik GIS, dan juga GLM (general linear model) digunakan dalam membangunkan model antara perikanan dan persekitaran bagi memperkirakan keutamaan persekitaran daripada ikan-ikan pelagik. Hasil kajian menunjukkan bahawa Laut Jawa secara bermusim dipenuhi oleh air lautan yang dibawa oleh arus ITF (Indonesian Throughflow). Pengaruh daripada ITF lebih ketara pada musim tengkujuh tenggara ketika arus-arus di Laut Jawa mengalir ke arah barat Pengaruhnya adalah minimum pada musim tengkujuh barat laut ketika arus di Laut Jawa mengalir ke arah timur. Laut ini mempunyai stabilan termal yang tinggi dengan purata bulanan SST 28.9 °C dan perbezaan antara gradient maksimum dan minimum adalah 2.0-3.5 °C. Kelimpahan fitoplankton cenderung untuk meningkat ke arah kawasan pantai barat dan kawasan-kawasan di luar pantai utara Jawa, pantai selatan Kalimantan, dan kawasan di sekitar pulau-pulau kecil yang terhampar di Laut Jawa. Korelasi di antara beberapa parameter-parameter oseanografi fizikal dan biologi ditunjukkan. Sumber-sumber perikanan pelagik di Laut Jawa mengalami perbezaan distribusi dan kelimpahan mengikut musim. Secara relatifnya, sumber ikan ini adalah rendah pada waktu musim tengkujuh barat laut (Disember-Mac), dan bertambah pada musim tengkujuh tenggara (Jun-September), dengan puncaknya pada penghujung musim tersebut. Kelimpahan sumber ini pada keseluruhannya berpunca daripada turun naiknya kelimpahan spesies utamanya, iaitu *Sardinella* spp di kawasan perairan pantai dan *Decapterus* spp di kawasan perairan dalam. Kedua-dua spesies ini membentuk masing-masing dengan purata 36% dan 32% daripada jumlah CPUE. Model GLM memberikan bukti bahawa spesies ikan pelagik memiliki had toleransi suhu sehingga 28.5 °C dan ikan-ikan pada suhu yang lebih rendah daripada ini menunjukkan hubungan positif dengan klorofil-a. Model tersebut juga mengungkap bahawa

pembolehubah-pembolehubah oseanografi (SST dan klorofil-a) menyumbang 54% kepada keragaman yang boleh diterangkan oleh pembolehubah-pembolehubah bebas dalam GLM, mengesahkan pentingnya pembolehubah-pembolehubah oseanografi tersebut dalam meramalkan tangkapan ikan pelagik. Walau bagaimanapun, perhubungan antara SST dan pemusatan-pemusatan klorofil-a adalah lemah. Model GIS menunjukkan kemampuannya bagi menggambarkan pola ruang bagi kepadatan ikan berhubung dengan pembolehubah persekitaran, terutamanya zooplankton, yang tidak dimasukkan dalam model GLM.

ACKNOWLEDGEMENTS

The assistance and services of various individuals and institutions, making this study possible are gratefully acknowledged. In short, the following particulars have to be mentioned for their regular motivation through my tenure of study period.

First and foremost, my sincere gratitude and appreciation are due to the chairman of my supervisory committee, Prof. Dr. Kamaruzaman Jusoff, for his professional guidance, encouragement and constructive criticisms from the beginning of this research till the final review of the manuscript.

I would like to express my sincere thanks to the other members of the committee, namely Prof. Dr. Fatimah Md. Yusoff, Deputy Director of Institute of Bioscience, Universiti Putra Malaysia, Prof. Dr. Mazlan Hashim, Head Department of Remote Sensing, Faculty of Engineering and Geoinformatics, University Technology Malaysia, Associate Prof. Dr. Khalid Samo, Research Fellow of the Institute of Oceanography, University College of Science and Technology Malaysia, Terengganu, for their advice and valuable comments during my study period.

Special thanks are due to Dr. Nani Hendiarti for valuable discussion concerning the interpretation of SeaWiFS data and also for her assistance in providing satellite derived chlorophyll-a data. Her smart discussion certainly improves the interpretation of the results.

I am indebted to the Head of Remote Sensing Laboratory of the Assessment and Application of Technology Board (BPPT), for allowing me to utilize the laboratory facilities to collect satellite derived sea surface temperature data. My acknowledgement also goes to the BPPT laboratory staff: Ir. Retno Andiastruti and Ir. Khairul Amri MS. Their practical help is highly appreciated.

I would like to express my sincere thanks to the PAATP of the Department of Agriculture of Indonesia for the scholarship award and the financial assistance, which made this study possible. I wish also to express my gratitude to Dr. Wudianto (Head of the Research Institute for Marine Fisheries), Dr. Subhat Nurhakim (Head of the Research Center for Capture Fisheries) for giving support to continue my study in Malaysia.

Special thanks are also due to Nurwianto, Sujianto, Suwardi and all crews of R.V. Mutiara IV, for their assistance during the fieldwork in the Java Sea. Finally, I address my deep gratitude to many people, whose names not be mentioned above.

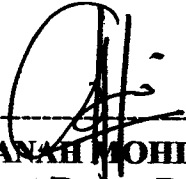
I certify that an Examination Committee met on 19 January 2006 to conduct the final examination of Wijopriono on his Doctor of Philosophy thesis entitled "Distribution of Pelagic Fish Species in the Java Sea from Remote Sensing Data" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Mohd. Ibrahim Hj. Mohamed, PhD
Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Shattri Mansor, PhD
Professor
Institute of Advance Technology
Universiti Putra Malaysia
(Internal Examiner)

Siti Khalijah Daud, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Sharifah Mastura Syed Abdullah, PhD
Professor
Faculty of Sciences and Technology
Universiti Kebangsaan Malaysia
(External Examiner)



HASANAH MOHD. GHAZALI, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: **27 MAR 2006**

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Kamaruzaman Jusoff, PhD

Professor

Faculty of Forestry

Universiti Putra Malaysia

(Chairman)

Fatimah Md. Yusoff, PhD

Professor

Institute of Bioscience

Universiti Putra Malaysia

(Member)

Mazlan Hashim, PhD

Professor

Faculty of Engineering and Geoinformatics

University of Technology Malaysia

(Member)

Khalid Samo, Ph.D.

Associate Professor

Institute of Oceanography

College University of Science and Technology Malaysia

(Member)



AINI IDERIS, PhD

Professor/Dean

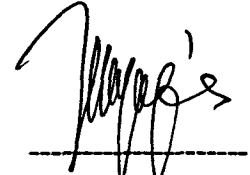
School of Graduate Studies

Universiti Putra Malaysia

Date: 13 APR 2006

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.


WIJOPRIONO

Date: 20/3/2006

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	vi
ACKNOWLEDGMENTS	ix
APPROVAL	xi
DECLARATION	xiii
LIST OF TABLES	xvi
LIST OF FIGURES	xvii
LIST OF ABBREVIATIONS	xxi
 CHAPTER	
 1. INTRODUCTION	 1.1
1.1 Background of the Study	1.1
1.2 Problems Statement	1.5
1.3 Objectives of the Study	1.8
 2 LITERATURE REVIEWS	 2.1
2.1 Interactions Between Fish Stocks and the Environment	2.1
2.2 Impacts of Environmental Variability on the Distribution and Abundance of Pelagic Fish	2.2
2.3 Utilization of Satellite Oceanography in Fisheries Studies	2.8
2.3.1 Satellite Derived Data Applied in Fisheries Studies	2.9
2.3.2 Satellite Sensors	2.16
2.3.3 Ocean Colour Remote Sensing	2.21
2.4 Hydro-acoustic Method For Fish Abundance Estimation	2.35
2.4.1 Target Strength	2.38
2.4.2 Size-Dependence of Target Strength	2.40
2.4.3 Measurement of Target Strength	2.43
2.4.4 Echo Integration	2.47
 3 DESCRIPTION OF THE STUDY AREA	 3.1
3.1 Geography and Bathymetry	3.1
3.2 Climate	3.5
3.3 Fisheries	3.8
3.3.1 Fisherman and Fleet Structure	3.8
3.3.2 Landing Places	3.10
3.3.3 Pelagic Fishery Resources and Exploitation	3.12
3.3.4 Fisheries Management and Regulation	3.17
 4 GENERAL METHODOLOGY	 4.1
4.1 The Study Framework	4.1
4.2 Fisheries Data	4.2
4.2.1 Commercial Catch Data	4.3
4.2.2 Fisheries Acoustic Data	4.5

4.3	Remote Sensing Data	4.9
4.3.1	SeaWiFS Derived Water Constituents	4.10
4.3.2	AVHRR-NOAA Derived Sea Surface Temperature	4.16
4.4	The Modular Ocean Data Assimilation System (MODAS)	4.17
4.5	Oceanographic Data	4.18
4.6	Methods of Analysis	4.21
5	SEASONAL VARIABILITY AND DYNAMICS OF OCEANOGRAPHIC FEATURES BASED ON REMOTE SENSING AND <i>IN SITU</i> MEASUREMENT DATA	5.1
5.1	Introduction	5.1
5.2	Materials and Methods	5.4
5.3	Results	5.8
5.3.1	Seasonal Pattern of the Currents and Water Temperature	5.8
5.3.2	Biological Productivity	5.19
5.4	Discussion	5.26
6	DISTRIBUTION AND ABUNDANCE OF SMALL PELAGIC FISH BASED ON COMMERCIAL FISHING AND HYDRO-ACOUSTICS DATA	6.1
6.1	Introduction	6.1
6.2	Materials and Methods	6.4
6.3	Results	6.10
6.3.1	Spatial and Seasonal Distribution of the Fish Species	6.10
6.3.2	Spatial Pattern of the Fish Distribution	6.22
6.4	Discussion	6.29
7	ESTIMATING ENVIRONMENTAL PREFERENCES OF THE JAVA SEA PELAGIC FISH SPECIES USING CATCH SIZE, REMOTE SENSING AND HYDRO-ACOUSTIC DATA	7.1
7.1	Introduction	7.1
7.2	Materials and Methods	7.4
7.3	Results	7.9
7.3.1	Models of Pelagic Fish Abundance and Environment	7.9
7.3.2	Estimation of environmental Preferences of the Fish	7.14
7.4	Discussion	7.19
8	CONCLUSIONS AND RECOMMENDATIONS	8.1
8.1	Conclusions	8.1
8.2	Recommendations	8.5
	REFERENCES	R.1
	APPENDICES	A.1
	BIODATA OF THE AUTHOR	B.1

LIST OF TABLES

Table		Page
2.1	The primary use of SeaWiFS channels	2.18
2.2	AVHRR/3 channel characteristics and their typical use	2.21
2.3	Main substances determining the optical properties for case 1 and case 2 waters	2.29
3.1	Catchments area and volume of some big rivers emptied into the Java Sea	3.4
3.2	The small pelagic fish species dominantly caught from the Java Sea	3.14
6.1	Definition of species categories used in the official statistic and landing places data records	6.11
6.2	Matrix correlation of Pearson's product moment between six species of main pelagic fishes based on their monthly average CPUE (1998-2002) from six fishing areas	6.20
7.1	A summary of the parameters used in the GLM analysis	7.7
7.2	Percentage of variance explained by the GLM parameters	7.11

LIST OF FIGURES

Figure	Page
2.1 SeaStar spacecraft and SeaWiFS sensor	2.17
2.2 Composition of spectral radiance variables received by the satellite sensor	2.23
2.3 Light irradiance and its interaction just below and above the sea surface	2.24
2.4 Spectral absorption coefficients for pure seawater, chlorophyll <i>a</i> (1 mg/m ³) and yellow substances (1 mg/dm ³)	2.28
2.5 The echosounding system	2.44
2.6 Principle of split-beam echosounder	2.45
2.7 Principles of echo integration	2.47
3.1 Geographic location of the Java Sea, Indonesia	3.2
3.2 Profile of bathymetry of the Java Sea	3.3
3.3 Winds vector derived from QUICKSCAT	3.6
3.4 The principal fishing fleet of small pelagic fishery in the Java Sea	3.9
3.5 Landing places for small pelagic fishing fleet in the north coast of the Java Sea	3.11
3.6 Development of the fishing grounds extension of small pelagic fishery in the Java Sea	3.13
3.7 The small pelagic fish species dominantly caught from the Java Sea	3.15
4.1 Framework of the study	4.2
4.2 Tracks of hydro-acoustic survey in September-October 2002	4.7
4.3 General steps for processing different levels of SeaWiFS data	4.11
4.4 Maps of the sampling sites during oceanographic cruises	4.19
4.5 Oceanographic parameters data collection	4.20

5.1	CTD-Current meter Valeport 308 used for measuring temperature, salinity, currents and depth profiles	5.5
5.2	Surface currents and sea surface temperature (SST) of the Java Sea derived from MODAS	5.9
5.3	Currents direction and velocity at the surface layer and 10 m depth layer, derived from <i>insitu</i> measurement during pre-northwest monsoon (October 2002)	5.11
5.4	Currents direction and velocity at 20 m depth layer and 30 m depth layer, derived from <i>insitu</i> measurement during pre-northwest monsoon (October 2002)	5.12
5.5	Sea surface temperature in 11 January 2002 and 8 July 2002 derived from AVHRR-NOAA with 1 km spatial resolution	5.13
5.6	Sea surface temperature in 2 April 2002 and 22 October 2002 derived from AVHRR-NOAA with 1 km spatial resolution	5.14
5.7	Result of regression (matched up) analysis between SST satellite derived data and SST derived from <i>in situ</i> measurement in the Java Sea	5.14
5.8	Monthly sea surface temperature of the Java Sea derived from AVHRR-NOAA pathfinder 5.0 with spatial resolution of 4 km	5.16
5.9	Contours of vertical temperature of the Java Sea during pre-northwest monsoon (October 2002)	5.17
5.10	Vertical profiles of temperature in selected stations measured during the cruise of September-October 2002	5.18
5.11	SeaWiFS derived LAC data with spatial resolution of 1 km showing the distribution of chlorophyll-a on 2 August 2001	5.19
5.12	Monthly GAC data derived from SeaWiFS with spatial resolution of 5 km showing the distribution of chlorophyll-a in September 2001 and November 2002	5.20
5.13	Result of regression (matched up) analysis between chlorophyll-a satellite derived data and chlorophyll-a derived from <i>in situ</i> measurement in the Java Sea	5.21
5.14	Distribution of chlorophyll-a concentration derived from <i>insitu</i> measurement in October 2002 and SeaWiFS GAC data in October 2001	5.22
5.15	Distribution of phytoplankton in October 2002 mapped by classed interval and contour plot	5.24

5.16	Distribution of Zooplankton in October 2002 mapped by classed interval and contour plot	5.25
6.1	Geographical location of sampling sites and the main fishing areas of the fleets (purse seiners)	6.6
6.2	Trends of CPUE of pelagic fish species averaged from 1998-2002	6.12
6.3	Seasonal variation of CPUE of each pelagic fish species in the area offshore and inshore, averaged from 1998-2002	6.13
6.4	Percentage of CPUE of each pelagic fish species relative to the total species in the area offshore and inshore averaged from 1998-2002.	6.14
6.5	Map and surface plot showing the main fishing areas and seasonal relative abundance of pelagic fishes according to fishing area and season (month)	6.16
6.6	Surface plots showing the seasonal relative abundance of <i>Decapterus</i> spp, <i>Sardinella</i> spp, <i>Rastrelliger</i> spp, according to fishing area and season (month)	6.17
6.7	Surface plots showing the seasonal relative abundance of <i>S. crumenophthalmus</i> , <i>A. sirm</i> , <i>A.thazard</i> and <i>E. affinis</i> , according to fishing area and season (month)	6.18
6.8	Hierarchical clustering, based on Euclidean distance, of the six species of main pelagic fishes combined from six fishing areas	6.20
6.9	Species ordination, based on principal component analysis (PCA) upon catch weights (monthly average CPUE 1998-2002), of main pelagic fishes combined from six fishing areas	6.21
6.10	Horizontal distribution of pelagic fish resources within the entire water column in the Java Sea in September-October 2002	6.24
5.11	Horizontal distribution of pelagic fish resources in the depth layers 10-25m	6.25
5.12	Horizontal distribution of pelagic fish resources in the depth layers 25-50m	6.26
5.13	Horizontal distribution of pelagic fish resources in the depth layers 50-75m	6.26
5.14	Vertical distribution of pelagic fish resources along the two meridional transects western and eastern parts of the survey area	6.28

7.1	Bivariate GLMs showing the relationships of response and individual predictors	7.10
7.2	GIS model showing spatial relations between fish density distributions and: (a) sea surface temperature, (b) zooplankton	7.12
7.3	GIS model showing spatial relations between fish density distribution and: (a) phytoplankton, (b) chlorophyll-a.	7.14
7.4	Mean seasonal variability of pelagic fish catches in the Java Sea	7.15
7.5	Relationship between pelagic fish catches and SST in the different ranges of SST	7.16
7.6	Relationship between pelagic fish catches and chlorophyll-a in different ranges of SST	7.17

LIST OF ABBREVIATIONS

ACS	Attitude Control System
ADEOS	Advanced Earth Observation Satellite
AVHRR	Advanced Very High Resolution Radiometer
BURS	Bradford University Remote Sensing
C	Celsius
CDA	Command and Data Acquisition
CDOM	Colored Dissolved Organic Matter
CPUE	Catch per Unit Effort
CRISP	Centre for Remote Imaging, Sensing and Processing
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTD	Conductivity Temperature Depth
CZCS	Coastal Zone Color Scanner
EMR	Electromagnetic Radiation
ESDU	Elementary Sampling Distance Unit
FAD's	Fish Aggregating Devices
GAC	Global Area Coverage
GIS	Geographic Information System
GLI	Global Imager
GLM	General Linier Model
GNP	Gross National Product
GOSSTCOMP	Global Operational Sea Surface Temperature Composite
GPS	Global Positioning System
GRT	Gross Registered Tonnage

GSFC	Goddard Space Flight Center
HRPT	High Resolution Picture Transmission
ITCZ	Inter-Tropical Convergence Zone
ITF	Indonesian Throughflow
JPL	Jet Propulsion Laboratory
LAC	Local Area Coverage
l_c	Length at first capture
l_m	Length at first maturity
m	Meter
MCSST	Multi-channel Sea Surface Temperature
MERIS	Medium Resolution Imaging Spectrometer
mg	Milligram
MODAS	Modular Data Assimilation System
MODIS	Moderate Resolution Imaging Spectroradiometer
MSY	Maximum Sustainable Yield
NASA	National Aeronautics and Space Administration
NIR	Near Infrared
nm	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Laboratory
NW	Northwest
OCTS	Ocean Color and Temperature Scanner
p	Probability
PCA	Principal Component Analysis
PODAAC	Physical Oceanography Data Active Archive Center

POES	Polar-orbiting Operational Environmental Satellite
R/V	Research Vessel
SE	Southeast
SeaDAS	SeaWiFS Data Analysis System
SeaWiFS	Sea-Viewing Wide Field of View Sensor
SSH	Sea Surface Height
SST	Sea Surface Temperature
ST	Station
TAC	Total Allowable Catch
TS	Target Strength
TVG	Time Varied Gain